# FOUR METHODS OF ASSEMBLING INSTITUTIONAL GROCERY ORDERS

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UNITED STATES DEPARTMENT OF AGRICULTURE

## PREFACE

Under the provisions of the Agricultural Marketing Act of 1946, the U.S. Department of Agriculture has maintained an active program of research in the design and utilization of modern food-handling facilities. As a result of its research, the Department has examined many different ways of improving the handling of food products for many different types of firms. Institutional wholesale grocers, suppliers of products to food-service outlets, represent one kind of firm that has been the subject of USDA research.

This report is based on research to aid institutional wholesale grocers in reducing their warehousing costs by adopting the most efficient order-selection system suited to their needs. The study was conducted under the general supervision of Kenneth H. Brasfield, chief, Food Distribution Research Laboratory. Larz F. Kremer of the Market Operations Research Laboratory planned and made the drawings in this report.

Special appreciation is due the wholesale grocery firms that made their facilities available for detailed study.

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# FOUR METHODS OF ASSEMBLING INSTITUTIONAL GROCERY ORDERS

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## SUMMARY

Order assembly is the basic operation that determines much of the design of an overall warehouse system and requires a large part of the total labor needed to operate such a system. The four order-assembly methods discussed in this report are conventional, stock selector, "U" bay, and batch selection. Conventional selection consists of an order selector picking one or more orders and placing the assembled cases on a four-wheel handtruck. In stock selector selection a specialized piece of materials-handling equipment called a stock selector is utilized. In "U" bay selection a combination of tow tractors and conventional pallet racks arranged in a series of bays is used. Batch selection includes pallet jacks, pallets, bulk selection of orders, and a crew reselection, checking, and loading operation at the truck dock.

Warehouse layout is directly affected by the choice of order-selection method. Firms using conventional and batch selection often have layouts with aisles perpendicular to the truck docks and rail lines. Both pallet racks and floor storage are used extensively. This layout is typical of many in use by institutional grocers.

The layout for stock selectors features separate selection and reserve storage areas. Aisles are perpendicular to the truck docks and rail lines.

"U" bay selection requires a specialized layout. Conventional pallet racks are arranged perpendicular to main selection aisles in a series of bays. Fast-moving items are located in floor slots along the warehouse walls.

The choice of an order-selection system affects not only the cost of that operation but also the expense of receiving, restocking, checking, and truck loading. The "U" bay selection system offers the lowest overall labor cost—$63.94 per 1,000 cases. The low speed of the stock selector results in higher overall labor costs—$80.47 per 1,000 cases. The high labor requirements of conventional and batch selection result in almost the same overall labor costs—$94.03 and $94.74, respectively. These costs include $16.66 per 1,000 cases for supervision.

Not only are labor costs affected by the choice of an order-selection system but also equipment and facility charges. Overall costs, including labor, equipment, and facility charges, indicate that the "U" bay system costs the least—$127.45 per 1,000 cases and stock selectors cost the next lowest—$140.64. Conventional and batch selection are both hampered by low productivity, resulting in overall costs of $151.02 and $154.45, respectively.

Each wholesaler should examine his own particular circumstances and needs before selecting a warehouse system. Costs for labor, equipment, and buildings vary from place to place and warehouse expenses experienced by individual wholesalers may differ from the costs cited in this report. This variation may directly affect the relative economic merits of the four systems when they are compared by an individual firm.

In addition, each system has several advantages and disadvantages that cannot be meas-

ured directly in dollars and cents. Wholesale grocers should consider not only direct cost but flexibility, ease of expanding operations, handling special accounts, and possible future development in selecting a system for their particular use.

## INTRODUCTION

The costs associated with institutional grocery warehousing have increased rapidly. The average hourly wage of nonsupervisory employees in the wholesale trade as well as the costs of equipment and construction has increased substantially since 1966. For example, the average hourly wage of employees in the wholesale food industry increased over 41 percent between 1966 and 1972.[1]

Since 1966 the institutional grocery industry, and in particular its warehousing segment, has changed markedly. Many companies now have power equipment to handle merchandise. Computers and tabulating equipment are used extensively to prepare invoices, which list items in warehouse location sequence. Pallet racks and other storage aids are being utilized more widely.

The U.S. Department of Agriculture has maintained a research program to develop modern and efficient layouts and methods of operation to assist wholesale grocers in minimizing their marketing costs. Much of the previous research was concentrated on improving existing warehouse procedures through more efficient work methods, balanced work crews, better utilization of equipment, and improved layout. The previous Department research effort regarding moderate volume institutional wholesaling at the warehouse level was concerned with developing methods to determine costs of handling different size orders.[2] Specialized facilities for small firms are discussed in another report.[3] Earlier reports cover other aspects of the institutional grocery industry.[4]

Institutional wholesale grocers planning new facilities need to select a particular warehouse system to best suit their needs. The basic identifying feature of a grocery warehousing system is the method used to assemble orders. The importance of this function is illustrated by the large percentage of overall labor required in the warehouse for this function. In many companies approximately 50 percent of their labor is required for order selection compared with approximately 25 percent for receiving and internal movement, including railcar unloading, and the remaining labor is used for checking and truck loading. Four methods of assembly, each determining a warehouse system, were selected for study. They were considered representative of the warehousing practices of the institutional grocery industry in general.

The objectives of this study were as follows:

(1) To describe each order-selection method.

(2) To describe typical warehouse layouts used by wholesale grocers employing each order-selection system.

(3) To determine warehouse labor costs for order assembly, receiving, restocking, checking, and truck loading for each of the four order-selection methods.

(4) To determine other associated costs, such as equipment and space, using specific size firms as examples.

(5) To examine the relative merits of each system.

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[1] U.S. DEPARTMENT OF AGRICULTURE, ECONOMIC RESEARCH SERVICE. MARKETING AND TRANSPORTATION SITUATION. V. 160, 29 pp., and v. 184, 27 pp. 1966 and 1972.

[2] KARITAS, J. J. DETERMINING COSTS OF SERVICING WHOLESALE INSTITUTIONAL GROCERY ORDERS. U.S. Dept. Agr. Mktg. Res. Rpt. 752, 20 pp. 1966.

[3] MORRIS, J. N., JR. WAREHOUSE LAYOUT AND EQUIPMENT FOR INSTITUTIONAL WHOLESALE GROCERS IN MULTIPLE-OCCUPANCY BUILDINGS IN FOOD DISTRIBUTION CENTERS. U.S. Dept. Agr. Mktg. Res. Rpt. 927, 34 pp. 1972.

[4] WISCHLAEMPER, P., and BOUMA, J. C. SERVICES OF INSTITUTIONAL WHOLESALE GROCERS—OPINIONS OF FOODSERVICE OPERATORS. U.S. Dept. Agr. Mktg. Res. Rpt. 571, 75 pp. 1962.

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## DESCRIPTION OF ORDER-ASSEMBLY METHODS

During this study four order-assembly methods were examined. They included ways in which individual customer's orders were selected from storage and moved to the delivery truck. These methods were conventional, stock selector, "U" bay, and batch selection.

They all had several features in common. Each method was employed in a modern one-floor warehouse with high ceilings. Forklift trucks were used in three of the methods for receiving (moving incoming merchandise from over-the-road trucks to storage in the warehouse) and restocking (moving merchandise from bulk storage to locations from which orders would be selected). With the stock selector selection, the order-selector equipment was also utilized for receiving and restocking. Pallet racks were used for storage and provided an opportunity for selection. Each pallet position in the warehouse was identified by a location number. Tabulating equipment or computers were employed to prepare invoices, listing items by warehouse location in numerical sequence. Selectors (workers assembling orders) worked from these invoices. Handling equipment appropriate to the order-selection method was anticipated in layouts (internal warehouse arrangements) designed for each method.

### Conventional Selection

Conventional selection is one of the more widespread methods of assembling orders. With this method an order selector takes a four-wheel handtruck from the truck dock, carries one or more invoices, and assembles orders as he walks through the warehouse. After he has selected all the merchandise listed on the orders, the cycle is started again at the truck dock. Selection usually takes place from the bottom two or three pallet positions (space occupied in a pallet rack by one pallet) in conventional pallet racks.

Figure 1 illustrates conventional selection from this type of pallet rack. Upper tiers in these racks are used for reserve storage or for merchandise that will be relocated to pallet positions from which it will be later assembled into individual orders. After selection, assembled orders are checked for accuracy and then hand-stacked in delivery trucks.

### Stock Selector Selection

Stock selector selection was developed more recently than conventional selection. In this method a specialized piece of handling equipment called a stock selector is utilized. Figure 2 shows how merchandise is selected by workers using a stock selector. A stock selector is similar to a forklift truck, but its controls are mounted on a small platform directly behind the forks.

Using the stock selector, the operator picks up a pallet at the truck dock and starts his route. As he passes down a selection aisle, he raises the pallet and himself to the pallet position from which he wishes to select merchandise. Selection takes place from the bottom pallet to the pallet positions on the top of the pallet rack. The firms studied did not have reserve storage on the top of the pallet racks. Selection usually is limited to one area in the warehouse. After the selector finishes assembling his orders, he returns the loaded pallet to the truck dock and starts his next selection cycle. After the merchandise is checked, it is removed by hand from the pallets and stacked on the floor of delivery trucks.

### "U" Bay Selection

"U" bay selection combines power equipment and uniquely arranged conventional pallet racks. This method features tow tractors that pull four-wheel trucks for selection. Pallet racks are arranged perpendicular to main selection aisles in a series by bays, sometimes called "U" bays from the pallet position numbering order. Secondary aisles enter each bay. The selector travels in a manner similar to that in the other selection methods. As he passes down the main selection aisle, he bypasses those bays that do not contain merchandise he needs. When an order selector reaches a bay that does contain an item he needs, he stops the tow tractor, walks a short distance down the secondary aisle, se-

lects the item(s) from a pallet rack, and hand-carries them to his four-wheel truck (fig. 3). This procedure is repeated until he completes the route. After the assembled orders are checked, they are loaded by hand into delivery trucks.

## Batch Selection

In batch selection, power equipment is also used. The selector uses a pallet and electric pallet jack. The unique feature of this method is its organization. A recap sheet is prepared for an entire truckload. Each item on this sheet is selected at once and in sequence through the warehouse until the selection vehicle is filled. Loaded pallets are then placed near the rear of the delivery truck to be loaded.

The merchandise is reselected, checked, and loaded into the delivery truck by individual orders in one group operation. The dock crew usually consists of an order-caller-checker, two sorters stationed on the dock, and one truck loader. The order-caller-checker calls out items ordered from his copy of the invoice. Two sorters then select merchandise from the loaded pallets and place the cases on a short section of a power conveyor leading into the truck. At the other end of the conveyor, the truck loader removes the cases and stacks them on the truck floor. Figure 4 illustrates the reselection operation.


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FIGURE 1.—Conventional selection.

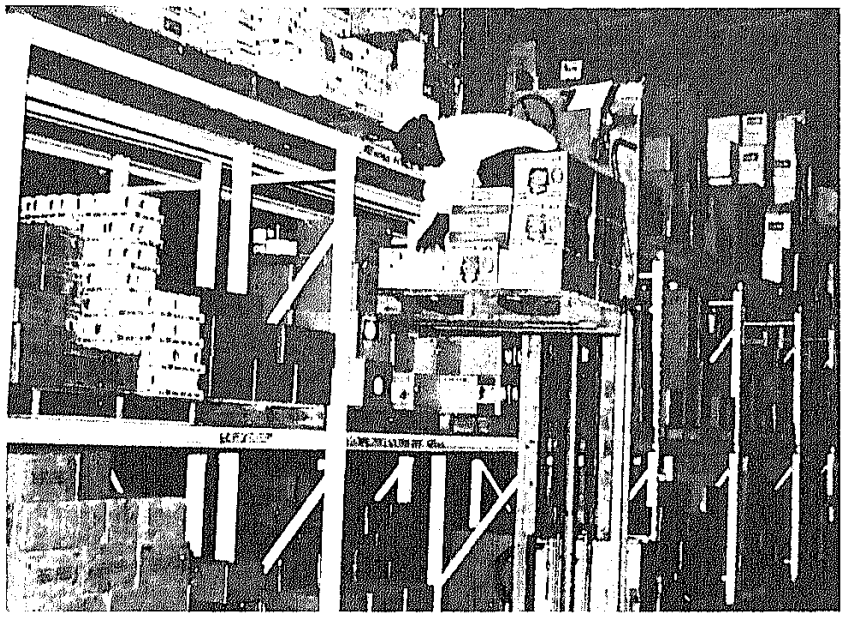

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FIGURE 2.—Stock selector selection.

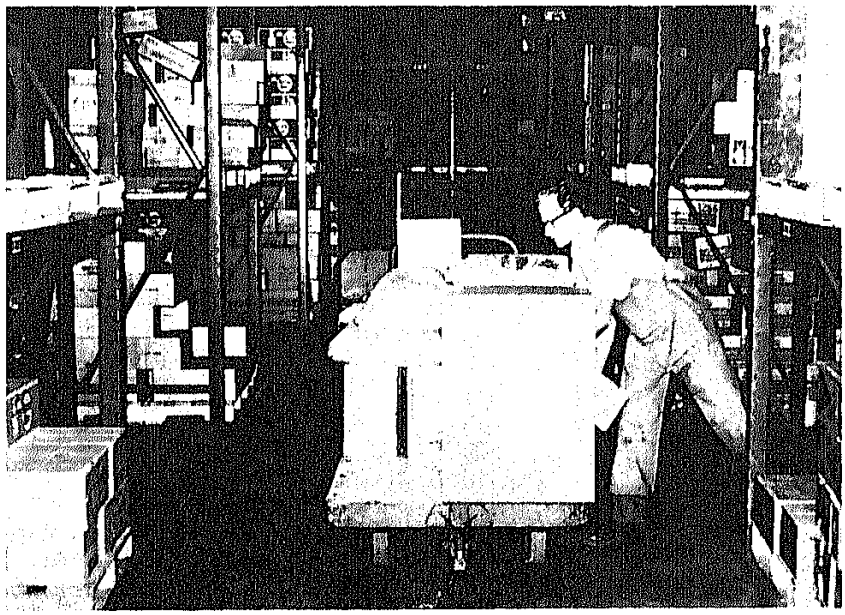

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FIGURE 3.—"U" bay selection.

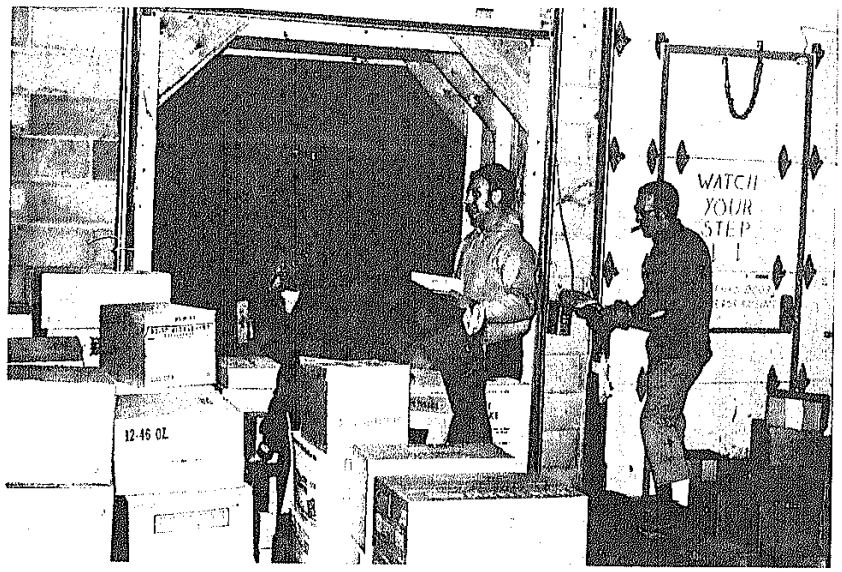


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FIGURE 4.—Batch reselection.

## LAYOUTS

All institutional wholesale grocers, regardless of the order-selection system they select, have certain common needs in their warehouses. Space must be provided for receiving, checking, and truck loading. Offices and restrooms must also be included in the layout. In addition, space must be provided for storing all products between receipt and sale. Aisles in the storage area must be wide enough for efficient handling and designed to be compatible with the order-selection method chosen by the wholesale grocer. Aisles 10 feet wide meet these needs and would allow selectors to pass one another with safety as well as allowing selectors and forklift trucks to operate along the same aisle.

To meet these needs, modern institutional grocery warehouses have many features in common. Sufficient space is available for receiving, checking, and truck loading. These areas are intended to provide space for separating the palletizing of incoming products from the movement of loaded pallets to storage in the receiving operations and to separate selection and truck-loading operations in order assembly.

Sufficient space is usually available over the truck-loading area for a mezzanine. Offices, restrooms, and, if needed, a spice room could be located on the mezzanine. These areas do not require high ceilings and should be separated from actual warehouse operations. Locating these areas on a mezzanine frees valuable first-floor space for more productive use.

Four types of storage are used by most firms having modern warehouses. They are bulk storage, storage on drive-in pallet racks, storage on conventional pallet racks, and shelf storage of handstacked products.

Bulk storage consists of fully loaded pallets of merchandise stacked directly on the floor and often one on top of the other. Some of the products stocked in the bulk storage areas are moved to other parts of the warehouse by forklift truck for later selection. Some fast-moving products (items sold in large quantities) may be stored in bulk storage areas for immediate selection.

Drive-in pallet racks (fig. 5) may be used to store large quantities of products, such as flour,

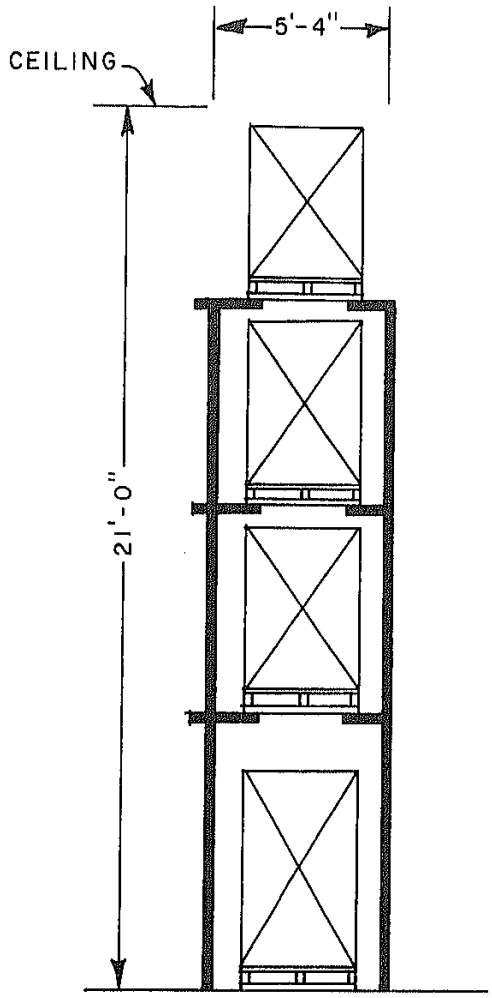


FIGURE 5.—Drive-in pallet rack.

sugar, cereals, and paper, that might be damaged by stacking pallets one over the other. Such racks can be used for order selection and consist of horizontal rails connected to vertical supports. The rails are arranged perpendicular to the selection aisle and support pallets, one high, in the rack. Stacking height may be adjusted by changing the height and spacing of the rails. Drive-in pallet racks often extend several pallets deep from an aisle and may be as high as the ceiling allows. They are closed at the rear and may be arranged back to back.

The most common method of high-stacked storage is on conventional pallet racks (fig. 6). These racks consist of horizontal bars connected to upright supports. The bars, which are parallel to the selection aisle, support pallet loads of products. Stacking heights can be changed on conventional pallet racks by adjusting the height of the bars. These racks can be altered to form shelving by replacing pallets with plywood sheets. Conventional pallet racks extend only one pallet deep from an aisle and several pallets high. Pallets of merchandise held in reserve can be placed one on top of the other over the highest set of supporting bars. Conventional pallet racks are usually arranged back-to-back, with one pallet directly accessible from an aisle or bay.

When choosing one of the order-selection methods, institutional wholesale grocers find it necessary to adopt modern warehouse layouts that will be compatible with their choice. These layouts (figs. 7–9) share the features of modern institutional grocery warehouses but differ from each other in certain specific details, reflecting the needs of the different order-assembly methods. The layouts are intended to illustrate the prineipal features of the wholesale facilities of the firms included in this study but do not represent the actual facilities of a specific firm. They are also intended to facilitate comparing the facility requirements of each order-assembly method and should not be considered as specific warehouse guides. All the layouts are based on warehouses of firms with approximately $6 million in annual sales. Coolers and freezers are not shown. Table 1 summarizes the physical features of each layout.

## Layout for Conventional and Batch Selection

Even though conventional and batch selection differ considerably in operation, they both require the same type of warehouse layout. This layout (fig. 7) is probably familiar to most institutional wholesale grocers. Aisles are perpendicular to the rail line and the doors in the truck receiving and shipping area. Aisles separate conventional pallet racks and bulk or floor storage. Selection and access aisles are combined to serve both functions. This particular layout features reserve storage on top of

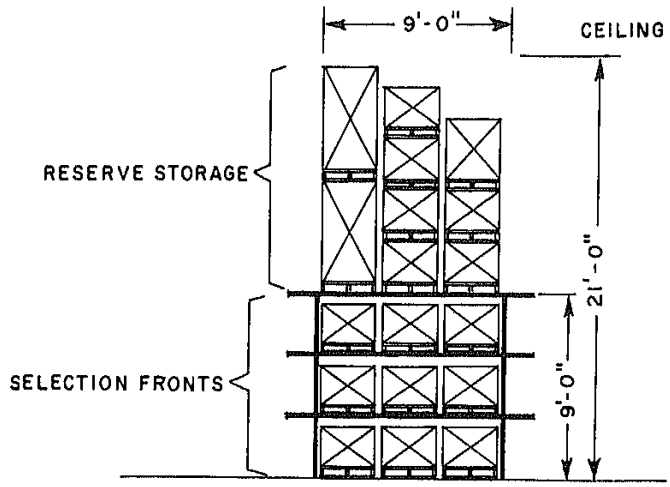


FIGURE 6.—Conventional pallet rack.

conventional pallet racks and in separate floor or bulk storage areas. Selection takes place from the bottom two or three pallet positions on the conventional pallet racks and from pallets of fast-moving items stacked directly on the floor in bulk storage areas. Because this layout is familiar to most wholesale grocers, it will be used as the standard when comparing other layouts.

## Layout for Stock Selector Selection

The layout designed for a wholesale grocer using stock selector trucks (fig. 8) features almost complete separation of selection and reserve. As the stock selector truck is designed to allow selection from the floor to the ceiling, there is no room for reserve storage on top of conventional pallet racks. Some firms using the stock selector method place reserve merchandise in the floor position of pallet racks. This feature can be incorporated into this layout. Pallet racks are perpendicular to the rail line and generally arranged in a conventional manner except for the separation of selection and reserve. Some floor storage is featured in this layout for fast-moving items.

This layout features nearly 5 percent more selection and nearly 20 percent more reserve storage capacity than a conventional layout. Additional storage capacity and floorspace are necessary for efficient operation.

## Layout for "U" Bay Selection

The warehouse layout used by wholesale grocers with a "U" bay selection system (fig.

TABLE 1.—*Size and capacity of warehouses illustrated by layouts for 4 methods of assembling institutional grocery orders*

| Selection layout | Aisles | Warehouse size | Selection pallet positions | Reserve pallet positions |
|---|---|---|---|---|
| | *Number* | *Square feet* | *Number* | *Number* |
| Conventional (fig. 7) | 12 | 45,771 | 2,516 | 4,858 |
| Stock selector (fig. 8) | 12 | 54,120 | 2,632 | 5,868 |
| "U" bay (fig. 9) | 6 | 55,626 | 2,832 | 5,682 |
| Batch (fig. 7) | 12 | 45,771 | 2,516 | 4,858 |

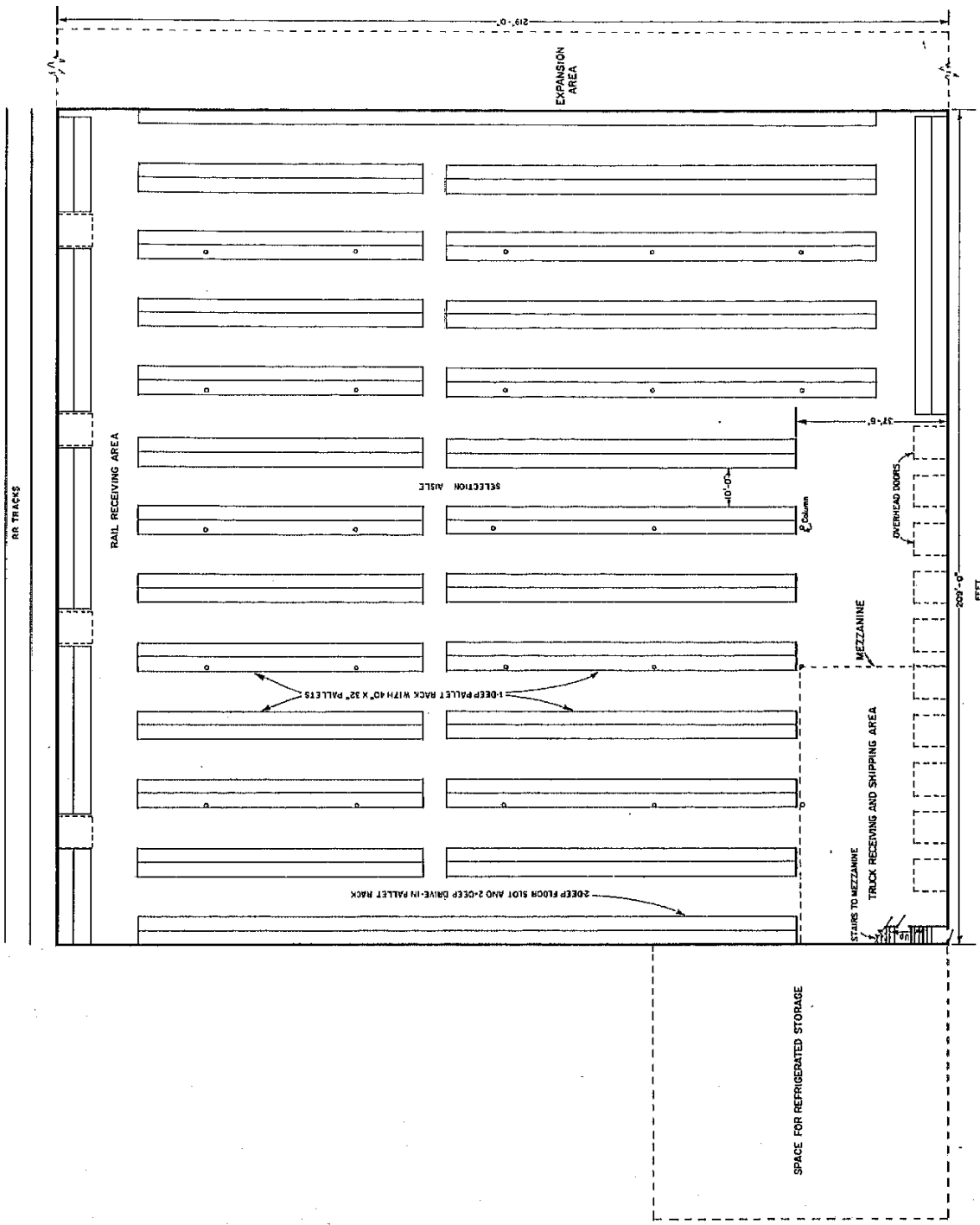


FIGURE 7.—Grocery warehouse layout for conventional and batch selection.

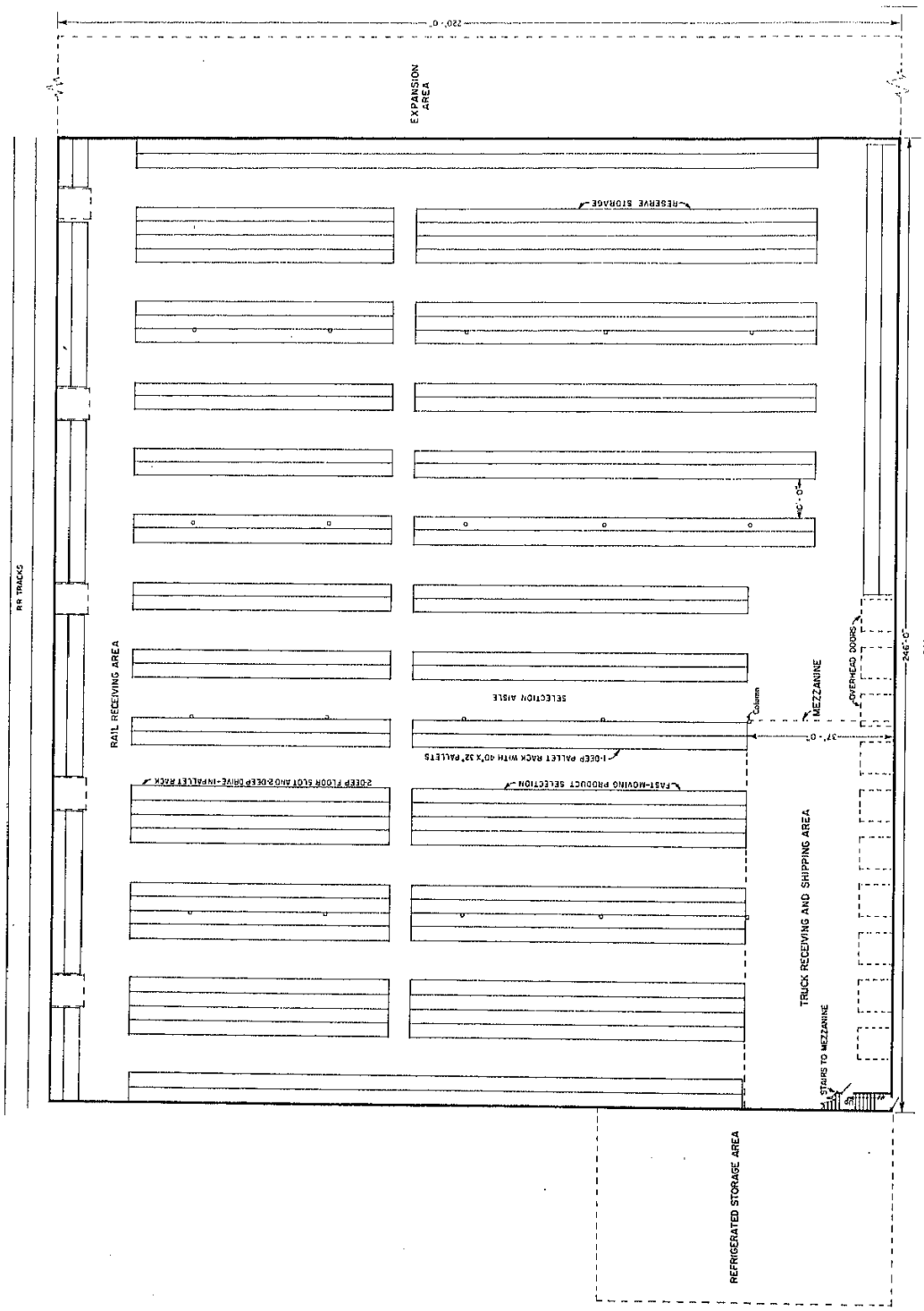


FIGURE 8.—Grocery warehouse layout for stock selector selection.

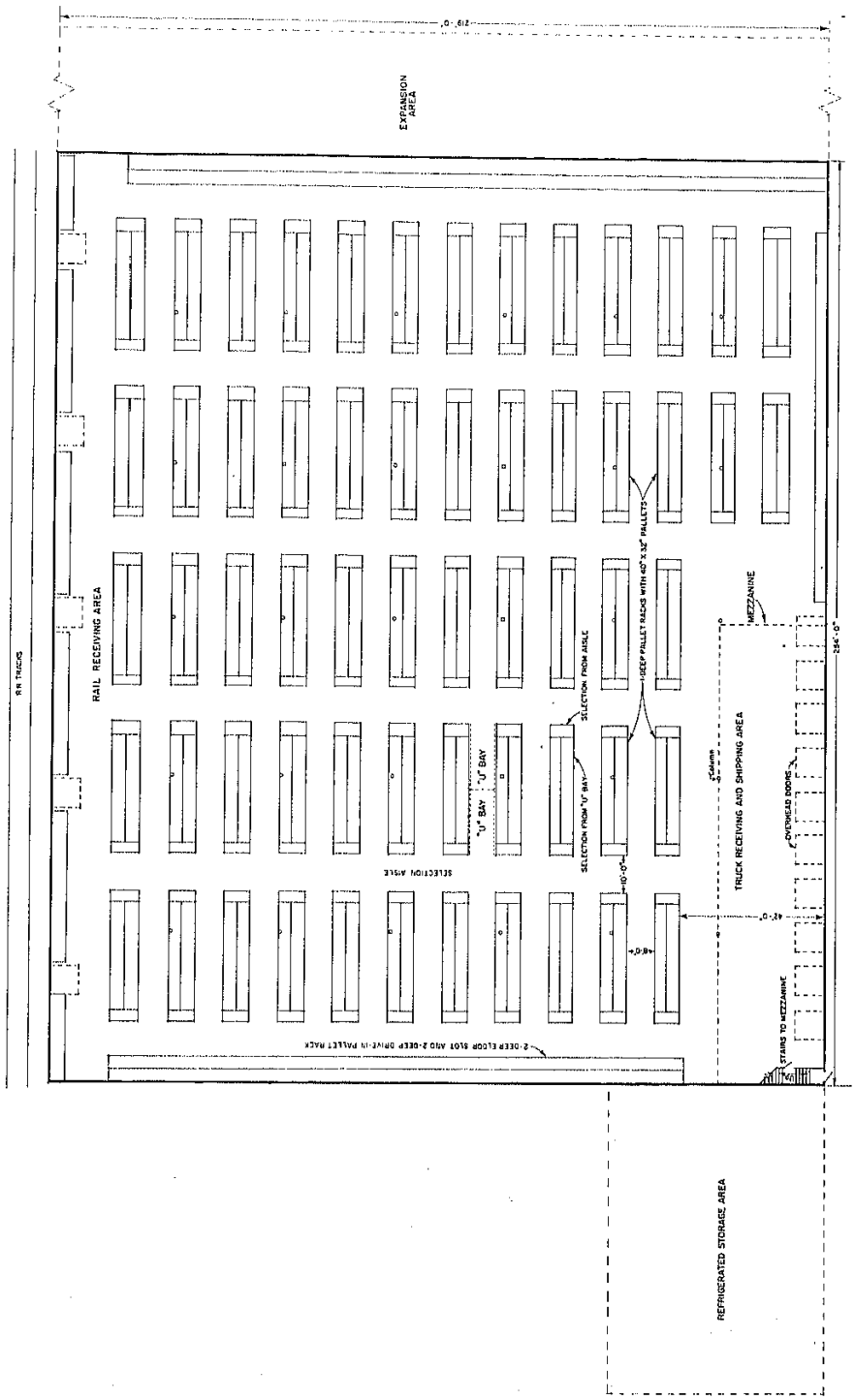


FIGURE 9.—Grocery warehouse layout for "U" bay selection.

9) differs considerably from a conventional warehouse. Conventional pallet racks are arranged perpendicular to main selection aisles in a series of bays (sometimes called "U" bays). Reserve storage is located on top of these racks. Merchandise in each bay is arranged so that the faster moving items are located adjacent to the selection aisles. Other faster moving products are also in floor slots along the warehouse walls. Some reserve storage would also be in this area.

This layout requires more space than the other layouts to allow efficient arrangement of pallet racks and selection aisles. As a result, the illustrated layout has more pallet positions available for selection (12 percent) and reserve (16 percent) as well as additional floorspace.

## WAREHOUSE OPERATING COSTS

When a wholesale grocer chooses an order-selection method, his choice affects receiving, restocking, checking, and truck-loading operations. To give a complete picture of the effects of choosing an order-selection method, other warehousing operations also need to be examined. The productivity of each major warehouse operation is examined in warehouses using each order-selection method. Costs are developed to better illustrate the advantages of each method.

All the firms included in the study conducted efficient warehouse operations. Computers were used to prepare invoices listing individual items in order of selection. Crews were organized and work was properly scheduled.

### Order Selection

Order-selector productivity varies considerably with order size (table 2). As might be expected, three of the order-selection methods improve in efficiency with the size of the order. Productivity of batch selection cannot be measured by order size because orders are determined by the capacity of the selection vehicle. Also, additional reselection of the batch order is required at the truck dock with this method of selecting orders.

The most efficient system from the standpoint of worker productivity is the "U" bay method with 154 cases followed by batch selection with 142 cases per man-hour. Batch-selection productivity will be lowered overall by additional

TABLE 2.—*Order-selector productivity by order size in warehouses using 4 methods of assembling institutional grocery orders* [1]

| Order size (number) | Conventional selection | | Stock selector selection | | "U" bay selection | |
|---|---|---|---|---|---|---|
| | Time per case | Cases per man-hour | Time per case | Cases per man-hour | Time per case | Cases per man-hour |
| | *Man-minutes* | *Number* | *Man-minutes* | *Number* | *Man-minutes* | *Number* |
| 1–2 | 2.00 | 30 | 0.85 | 70 | 0.84 | 71 |
| 3–4 | 1.50 | 40 | .72 | 83 | .55 | 109 |
| 5–6 | 1.33 | 45 | .70 | 85 | .52 | 115 |
| 7–8 | 1.15 | 52 | .58 | 103 | .44 | 136 |
| 9–10 | 1.09 | 55 | .51 | 118 | .42 | 142 |
| 11–12 | .99 | 61 | .51 | 118 | .41 | 146 |
| 13–14 | .91 | 66 | .49 | 122 | .41 | 146 |
| 15-more | .79 | 76 | .38 | 157 | .28 | 214 |
| Average | .82 | 73 | .47 | 127 | .39 | 154 |

[1] For batch selection, average time per case = 0.42 man-minute; average cases per man-hour = 142.

reselection required later. The comparatively low productivity of the stock selector reflects the time necessary for that equipment to lift the worker to upper selection slots. The low horizontal speed of the stock selector is also reflected in the lower productivity of this system with 127 cases per man-hour. All the order-selection methods using powered-selection equipment exceed the productivity of manual conventional selection with only 73 cases per man-hour.

Table 3 shows the average productivity rates experienced by wholesale grocers for the different order-selection methods converted into cost per 1,000 cases. This conversion is accomplished in the following manner. Time per cases was applied to a standard wage rate for all functions of $4.20 per hour. This rate was considered typical in the firms included in this study. Variation in cost among the different methods of selecting orders follows the same pattern as in table 2.

TABLE 3.—*Labor costs for order selection in warehouses using 4 methods of assembling institutional grocery orders*

| Selection method | Cases per man-hour | Cost per 1,000 cases [1] |
|---|---|---|
| | *Number* | |
| Conventional | 73 | $57.53 |
| Stock selector | 127 | 33.07 |
| "U" bay | 154 | 27.27 |
| Batch [2] | 142 | 29.57 |

[1] Based on wage rate of $4.20 per hour.
[2] Additional reselection required.

## Receiving

Receiving, the next warehouse operation, varies with the layout required for a particular selection method (table 4). Firms using conventional, "U" bay, and batch selection in their warehouses use forklift trucks to move incoming merchandise from the receiving dock to storage. The firms in this study that used stock selectors for selection also used this same equipment for receiving operations in lieu of forklift trucks.

The straight-through aisles of the layout designed for conventional and batch selection allow easy access between truck and rail receiving areas and the bulk storage areas. This easy access results in low receiving costs in warehouses using these two order-selection methods—$2.59 per 1,000 cases. The many corners to be turned causes higher receiving costs in the layout designed for "U" bay selection—$2.73 per 1,000 cases. The low speed of the stock selector equipment is reflected in the high receiving costs for the firms using this method of order selection—$2.69 per 1,000 cases. The firms that used stock selectors considered that their volume did not justify purchasing conventional forklift trucks to lower their receiving costs.

TABLE 4.—*Forklift operator labor costs for receiving in warehouse using 4 methods of assembling institutional grocery orders*

| Selection method | Cases per man-hour | Cost per 1,000 cases [1] |
|---|---|---|
| | *Number* | |
| Conventional | 1,620 | $2.59 |
| Stock selector [2] | 1,560 | 2.69 |
| "U" bay | 1,536 | 2.73 |
| Batch | 1,620 | 2.59 |

[1] Based on wage rate of $4.20 per hour.
[2] Stock selectors used in lieu of forklift trucks.

These costs were developed from typical receiving runs between receiving areas and reserve storage areas. The speed of the forklift trucks was applied to these runs for a round trip between dock and storage area. Time required for lifting a full load about 12 feet to storage, for dropping the empty forks, and for returning empty pallets to the receiving dock was included. Unavoidable delays of 15 percent were included in the production standards cited in table 4. No labor for clerical assistance or palletizing was included. Record keeping, checking incoming loads, and palletizing should not be affected by the choice of an order-selection method.

## Restocking

After merchandise has been received, it will often be moved from reserve storage to selection slots. This restocking operation will usually be conducted by a single employee with a forklift

truck in wholesale facilities where conventional, "U" bay, and batch selection methods are used. Firms using stock selector equipment for selection also use one or more of their stock selectors for restocking. Regardless of the order-selection method employed in the warehouse, some hand-stacking may be required in the operation. Merchandise left in the selection slot from a previous replenishment will be stacked on a new pallet or cases will be removed from a full pallet to a partly empty selection slot.

Productivity in restocking varies depending on the order-selection method and layout employed by a wholesale grocer. Table 5 shows this variation. As with receiving, the reason for the variation in restocking labor requirements is because of the difference between the layouts required for the four order-selection methods.

As with the receiving operations, warehouses designed for conventional and batch selection methods have the lowest restocking costs—$6.30 per 1,000 cases. The highest cost for restocking, $13.27, is incurred in a warehouse designed for use of a stock selector. The low operating speeds of this equipment hamper restocking operations as it had hampered receiving operations. The many corners to be turned in the warehouse designed for "U" bay selection methods result in a moderate restocking cost of $6.33 per 1,000 cases.

These costs are based on the warehouse layouts shown in figures 7–9. In addition, several assumptions were made concerning restocking operations. First, it was assumed that each pallet withdrawn from reserve storage would contain 25 cases of merchandise. Second, the relative percentage of pallet loads withdrawn from reserve storage slots over or near the selection pallet position and withdrawn from reserve storage in remote locations was dependent on the amount of such storage in each layout. Third, an average of five cases per pallet withdrawn from reserve storage would be handled manually. Fourth, approximately 15 percent of the total time required for restocking would be accounted for by delay and personal needs of the workers assigned to this operation. These assumptions were based on observations of actual warehouse operations made during this study.

TABLE 5.—*Selected labor costs for restocking in warehouses using 4 methods of assembling institutional grocery orders*

| Selection method | Cases per man-hour | Cost per 1,000 cases [1] |
|---|---|---|
| | *Number* | |
| Conventional | 666 | $6.30 |
| Stock selector | 316 | 13.27 |
| "U" bay | 663 | 6.33 |
| Batch | 666 | 6.30 |

[1] Based on wage rate of $4.20 per hour.

## Checking and Truck Loading

Checking and truck loading are two closely related operations in the warehouses included in this study. In batch selection the two functions must be considered together as a crew performs both operations at the same time. As with the other operations, checking and truck loading vary depending on the method of order selection used by the wholesale grocer (table 6).

Warehouse employees in both conventional and "U" bay selection load their orders on a four-wheel truck. Since the vehicle is similar, checking costs are the same for both systems—$3.48 per 1,000 cases. A worker using a stock selector stacks his orders on a pallet. Orders selected on pallets usually have some cases concealed in the center of the load. It is then necessary to move several cases in order to check those concealed. As a result, stock selector truck selection has the highest checking cost—$7.42 per 1,000 cases.

Truck loading is also affected by the type of selection vehicle used to pick orders. Pallets are easy to unload, resulting in a low truck-loading cost of $7.36 per 1,000 cases for the stock selector selection. Four-wheel trucks are slightly more difficult than pallets to move and unload. As a result, both conventional and "U" bay selection cost a little more—$7.47 per 1,000 cases to load trucks.

The overall cost of checking and truck loading with the batch selection system averages $39.62 per 1,000 cases. Interference among members of the group and difficulty in coordinating a multiman crew resulted in this very high cost.

TABLE 6.—*Labor costs for checking and truck loading in warehouses using 4 methods of assembling institutional grocery orders*

| Selection method | Checking | | Truck loading | |
|---|---|---|---|---|
| | Cases per man-hour | Cost per 1,000 cases [1] | Cases per man-hour | Cost per 1,000 cases [1] |
| | *Number* | | *Number* | |
| Conventional | 1,200 | $3.48 | 562 | $7.47 |
| Stock selector | 566 | 7.42 | 571 | 7.36 |
| "U" bay | 1,200 | 3.48 | 562 | 7.47 |
| Batch [2] | -- | -- | 106 | 39.62 |

[1] Based on wage rate of $4.20 per hour.
[2] Since checking and truck loading are combined in warehouses using this method, both costs are summarized under truck loading.

## Other Warehouse Costs

Other warehouse costs besides labor expenses must be considered when deciding which order-selection method to adopt. Because of the different layouts and procedures for different order-selection methods, total labor costs including supervision will vary, equipment costs will be different, and building rentals will also differ. Unless otherwise noted, all costs are based on firms with approximately $6 million in annual sales.

### Total Labor Costs

Warehouse supervision is usually a reasonably fixed expense when labor requirements do not vary greatly among firms. Supervision charges were estimated at $16.66 per 1,000 cases for each selection method.

Total selected warehouse labor costs vary with the type of order-selection method (table 7). "U" bay selection has the lowest overall labor cost—$63.94. The low speed of the stock selector results in higher overall labor costs —$80.47 per 1,000 cases. The high labor requirements of conventional and batch selection result in almost the same overall costs—$94.03 and $94.74, respectively.

### Equipment Costs

Equipment costs include only charges for forklift trucks and selection vehicles, which are the only types of equipment directly affected by the choice of an order-selection system. The total charge for forklift trucks and selection vehicles varies depending on the type of order-selection system used in the warehouse (table 8). Detailed equipment requirements, costs, and methodology for each selection sys-

TABLE 7.—*Total selected labor costs per 1,000 cases in warehouses using 4 methods of assembling institutional grocery orders with $6 million in annual sales* [1]

| Selection method | Order selection | Receiving | Restocking | Checking | Truck loading | Total [2] |
|---|---|---|---|---|---|---|
| Conventional | $57.53 | $2.50 | $6.30 | $3.48 | $7.47 | $94.03 |
| Stock selector | 33.07 | 2.69 | 13.27 | 7.42 | 7.36 | 80.47 |
| "U" bay | 27.27 | 2.73 | 6.33 | 3.48 | 7.47 | 63.94 |
| Batch | 29.57 | 2.59 | 6.30 | ([3]) | 39.62 | 94.74 |

[1] Based on data in tables 3–6 and on wage rate of $4.20 per hour.
[2] Includes supervision charges of $16.66 for each selection method.
[3] Checking costs included under truck loading.

TABLE 8.—*Selected equipment costs in warehouses using 4 methods of assembling institutional grocery orders with $6 million in annual sales*

| Selection method | Forklift trucks | Selection vehicles | Total | Cost per 1,000 cases [1] |
|---|---|---|---|---|
| Conventional | $5,463 | $404 | $5,867 | $4.88 |
| Stock selector | 0 | 8,752 | 8,752 | 7.29 |
| "U" bay | 5,463 | 3,234 | 8,697 | 7.24 |
| Batch | 5,463 | 3,660 | 9,123 | 7.60 |

[1] Based on average value of $5 per case.

tem are given in the appendix and in table 11.

As expected, manual selection requires the lowest investment in materials-handling equipment. Forklift trucks are required for receiving and restocking selection slots. Four-wheel handtrucks are used for selection; this type of equipment has low initial cost and requires little or no maintenance. A total of $4.88 per 1,000 cases is required for equipment investment with conventional selection.

Stock selector selection also requires a limited amount of equipment. Firms using this system increase the utilization of their equipment by using their stock selectors for receiving, restocking, and order selection. This decision limits equipment investment to $7.29 per 1,000 cases. Some firms may decide to use a forklift truck for receiving and restocking operations. If forklift trucks are purchased for this purpose, equipment cost will be greater.

"U" bay selection requires still more equipment investment. Although high selector productivity holds down the number of selection vehicles, a fairly high unit cost for selector vehicles results in an equipment investment of $7.24 per 1,000 cases.

Batch selection develops the highest equipment costs—$7.60 per 1,000 cases. There are three basic reasons for this high cost. First, batch selection does not have the low equipment requirements of conventional selection. Second, it does not have the use of flexible selection equipment that could be used for receiving and restocking as well as for order picking as does order-selector selection. Third, the higher selector productivity of "U" bay selection allows fewer tractors to be used when compared with the number of pallet jacks required for the firm using batch selection.

## Facility Costs

Facility costs are the charges for building and pallet racks used in the warehouses (figs. 7–9). For a more meaningful comparison among the different layouts, only the direct amortized costs of the building and pallet racks are included. Other costs, such as maintenance and heating, are not included.

The square footage of the layouts (figs. 7–9) was adjusted so that each layout provides the same number of reserve and selection slots. See the appendix for the floorspace changes required for these adjustments. The layout for conventional and batch selection (fig. 7) was used as the basis with which the other layouts were compared.

The adjusted facility costs vary depending on the order-selection system used (table 9). As expected, conventional and batch selection require the same investment for building and pallet racks—$52.11 per 1,000 cases. Both of these selection methods are used by warehouses with the same type of layout. Stock selector selection requires less investment for pallet racks because floor slots are used extensively for reserve storage as well as fast-moving items. This extensive use of floor slots and their associated aisles increases the need for warehouse space, resulting in an overall investment requirement of $52.88 per 1,000 cases. "U"

TABLE 9.—*Building and pallet rack costs for warehouses designed for 4 methods of assembling institutional grocery orders with $6 million in annual sales*

| Selection method | Building [1] | | | Pallet racks [2] | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Investment | Annual cost | Cost per 1,000 cases | Investment | Annual cost | Cost per 1,000 cases | Investment | Annual cost | Cost per 1,000 cases |
| Conventional | $640,794 | $54,986 | $45.82 | $62,912 | $7,548 | $6.29 | $703,706 | $62,534 | $52.11 |
| Stock selector | 685,244 | 58,800 | 49.00 | 38,850 | 4,661 | 3.88 | 724,094 | 63,461 | 52.88 |
| "U" bay | 699,048 | 59,985 | 49.98 | 62,912 | 7,548 | 6.29 | 761,960 | 67,533 | 56.27 |
| Batch | 640,794 | 54,986 | 45.82 | 62,912 | 7,548 | 6.29 | 703,706 | 62,534 | 52.11 |

[1] Based on an overall warehouse construction cost of $14 per square foot, 7-percent annual interest, and amortization over 25 years.
[2] See appendix. Rack requirements adjusted to reflect floorspace changes.

bay selection requires the highest overall total investment in pallet racks and warehouse space. This system requires more floorspace than the conventional and batch selection systems. Overall investment for the firms using "U" bay order selection totals $56.27 per 1,000 cases.

## Total Costs

Total selected costs vary among the order-selection systems (table 10). Overall the "U" bay method has the lowest cost—$127.45 per 1,000 cases. High selector productivity is the major reason for this low cost. The benefits of high selector productivity, however, are partly offset by higher warehouse space requirements. The stock selectors have the next lowest overall cost—$140.64 per 1,000 cases. This method does not have as high a selector productivity as does the "U" bay system but makes better use of available warehouse space.

Both the "U" bay and the stock selector methods share one common but important feature—increasing the number of selection slots along a given length of selection aisle. This feature allows selectors to easily bypass unwanted selection slots and thus shortens travel distance and results in a higher order-selection rate.

Batch and conventional selection are both hampered by low productivity. Batch selection, with its multiple handling of each case, has the highest overall cost of the four systems—$154.45. Manual conventional selection, with its dependence on physical effort, develops an overall cost of $151.02 per 1,000 cases. Both systems are expensive in terms of manpower. Lower equipment costs with the conventional system do not offset a low selector productivity. A higher equipment investment for batch selection does not provide an adequate return in terms of selector, checking, and loading efficiency.

Both batch and conventional selection efficiently use available warehouse space. This economy in warehouse space does not, however, offset the systems' disadvantages.

TABLE 10.—*Total selected costs per 1,000 cases in warehouses using 4 methods of assembling institutional grocery orders with $6 million in annual sales* [1]

| Selection method | Labor | Equipment | Building and pallet racks | Total |
|---|---|---|---|---|
| Conventional | $94.03 | $4.88 | $52.11 | $151.02 |
| Stock selector | 80.47 | 7.29 | 52.88 | 140.64 |
| "U" bay | 63.94 | 7.24 | 56.27 | 127.45 |
| Batch | 94.74 | 7.60 | 52.11 | 154.45 |

[1] Based on data in tables 7–9.

## OTHER CONSIDERATIONS

A wholesale grocer considering adopting one of the four systems evaluated in this report should examine each from the standpoint of his firm's needs. Particular circumstances may require that a company adopt one system or features of several systems that another firm would not find suitable to its operations. In addition, wage rates, equipment charges, and building costs may vary with location and be higher or lower than those expenses cited in this report. Any of these factors may make one or the other of the systems more economical than would be indicated by this report.

In addition, some of the relative advantages of the four systems for assembling institutional grocery orders cannot be measured in terms of cost. Special features of one or the other order-selection systems may be important enough to a particular wholesale grocer to offset the effect of higher costs when compared with another system.

Conventional selection has the advantage of flexibility. Low equipment investment required for each selector allows companies using this system to quickly vary the number of selectors to meet peak needs. Additional unused selection equipment can be kept on hand for this purpose. The other three systems require expensive equipment for each selector working at a given time. With these systems it may be too expensive to add selectors to meet a temporary peak demand. This difficulty often requires that selection be conducted during more than one shift.

Versions of the stock selector system have been developed that are flexible and also allow a high selector productivity. The stock selectors in this study have limited vertical reach and often are difficult to control. These factors cause a limited selector productivity. High investment requirements lead to using the machines for receiving operations, for which they were not designed. Newer machines now being installed in the institutional grocery industry feature rail guides and a very high vertical reach (fig. 10). These factors may result in a high enough selector productivity to offset high investment requirements.

The "U" bay selection system offers a particular advantage to a growing firm. The tow tractors and trucks used in this order-selection system can be adjusted to provide additional carrying capacity by adding an additional truck. Firms using "U" bay selection system have found that two trucks can be used behind a tractor, even in a narrow-aisle warehouse. The other order-selection systems would be difficult to adapt in this manner.

Batch selection lends itself to handling large accounts and ordering a limited number of items. When this type of account is serviced, pallet quantities of merchandise can be moved directly from storage to the delivery truck. The other three systems could be adapted similarly.

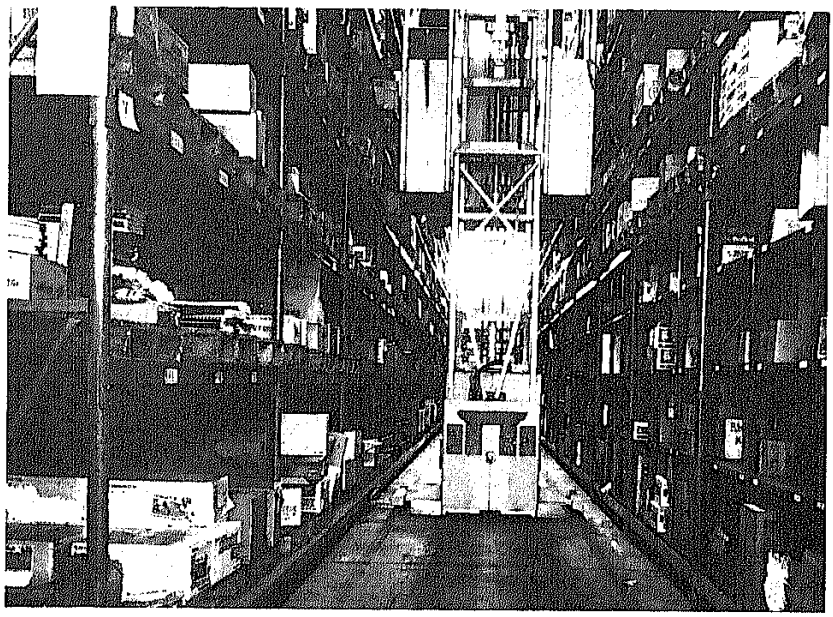

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FIGURE 10.—Rail-directed, high-lift stock selector.

## OTHER ORDER-ASSEMBLY METHODS

Many firms use variations of the order-assembly methods discussed in this report. Conventional selection often employs powered selection equipment such as pallet jacks and tow tractors. Firms using stock selectors may employ advanced equipment such as the high-lift selector (fig. 10). "U" bay selection could employ manual equipment, pallet jacks, or almost any other type of order-selection equipment as well as the tow tractors and trucks described in this report. Batch selection is similarly flexible as to the type of materials-handling equipment required for efficient operation. Numerous variations of internal layout are also possible. Both handling equipment and warehouse design will usually reflect the specific needs of individual wholesalers.

Other completely different order-assembly methods are used by institutional wholesale grocers. A wide range of materials-handling equipment, organization, and layout is featured. Some firms extensively use conveyors, live storage, and remote control of selection. Investigation of such mechanized warehouse systems is now underway for general-line wholesalers. The findings may be applicable as well to institutional wholesale grocers.

It is beyond the scope of this report to evaluate all possible variations in the numerous order-assembly methods used by institutional wholesale grocers. Firms with order-selection methods different from those discussed here can use a similar means of analysis to evaluate their own system.

## APPENDIX

### Time Study

Time study was the major research technique used in collecting data from the firms participating in this study. Such studies were made of each major warehouse operation in the participating firms.

Time study is defined as "the analysis of a given operation to determine the elements of

work required to perform it, the order in which these elements occur, and the times which are required to perform them effectively."[1] Each warehouse operation was broken down into elements and each element was timed with a stopwatch and related to production (cases per man-hour). At the same time, the worker studied was rated as to speed on a scale of 100, which equals normal. For example, a worker rated at 120 would be considered to be working 20 percent faster than a normal rate. After each element had been timed extensively, averages were calculated and adjusted with the rating factor to represent normal effort. For this study, the sample size selected was large enough to insure that the chances were 95 out of 100 that the calculated average for each element would not be in error by more than 5 percent.[2] Allowances for fatigue and personal needs were than added to the results.

After the time studies were completed, the results were used as the basis for tables 2, 3, and 6. Time studies and published equipment-operating speeds were utilized in developing the information in tables 4 and 5.

## Equipment Costs

The amount and costs of certain equipment needed by example firms using each of the four order-selection systems discussed in this report are given in table 11. Only equipment required for a particular handling system is included. Other equipment will remain the same regardless of the order-selection system adopted or will not significantly affect overall costs of the selection system. In this report each firm was assumed to have approximately $6 million in annual sales.

The number of selection vehicles needed for each order-selection system is determined by the production rates given in table 2 and is calculated in the following manner: First, an average value of $5 per case is assumed. For the example firms this would be the equivalent of 1,200,000 cases per year ($6 million divided by $5 equals 1,200,000 cases). If the companies operate on an average of 250 days per year, approximately 4,800 cases would have to be assembled daily. Average production rates for selection multiplied by the working hours each day (8 hours) are divided into the 4,800 cases to determine the approximate number of selection vehicles needed to handle the daily requirements. For stock selectors the calculations would be as follows: 127 multiplied by 8 and divided into 4,800 equals 4.72 or five stock selectors. These results should be considered only as a guide. Particular circumstances of individual firms may dictate additional equipment.

A minimum of three forklift trucks was considered necessary for a firm with $6 million in annual sales. This particular equipment is used for many different purposes in the overall warehouse operations. In stock selector selection, the stock selectors were used in lieu of forklift trucks for receiving and restocking. It is necessary, however, to perform receiving operations during the day and order assembly at night to avoid the need to purchase forklift trucks.

"U" bay and conventional selection pose certain problems in determining equipment requirements. Both types of selection use equipment not only for selection but also for temporary storage of assembled orders. In "U" bay selection, the number of tow tractors is based on the production rates given in table 2. The number of trucks also used in this system is based on the order-selection productivity of the system as well as the need for additional trucks to store assembled orders. Equipment requirements for conventional selection are calculated on a similar basis. Sufficient four-wheel handtrucks are shown in table 11 for order-selection use, for temporary storage of assembled orders, and for checking and loading the orders.

Depreciation is calculated on a straight-line basis and assumes no salvage value. The depreciation period is based on U.S. Internal Revenue Service Bulletin "F."

Interest rates are based on the return from alternative investment of capital and should

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[1] MAYNARD, H. B. INDUSTRIAL ENGINEERING HANDBOOK. 1847 pp. McGraw-Hill Book Co., Inc., New York, N.Y. 1963.

[2] NIEBEL, B. W. MOTION AND TIME STUDY. 494 pp. Richard D. Irwin, Inc., Homewood, Ill. 1958.

TABLE 11.—*Selected equipment requirements and costs in warehouses using 4 methods of assembling institutional grocery orders with $6 million in annual sales*

| Selection method and equipment | Amount [1] | Unit price [2] | Years depreciated [3] | Investment | Ownership costs | | | | Maintenance and other costs | Total annual costs |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Depreciation [4] | Interest (6 percent) [5] | Insurance and taxes (4 percent) | Total | | |
| | *Number* | | *Number* | | | | | | | |
| *Conventional* | | | | | | | | | | |
| Four-wheel handtrucks (2,000-pound capacity, size 30 by 60 inch) | 24 | $100 | 12.0 | $2,400 | $200 | $72 | $96 | $368 | $36 | $404 |
| Counterbalanced forklift truck (2,500-pound capacity, 24-volt electric, stand-up rider type, 167-inch lift) | 3 | 7,300 | 10.0 | 21,900 | 2,190 | 657 | 876 | 3,723 | 329 | 4,052 |
| Battery | 3 | 1,391 | 6.3 | 4,173 | 662 | 125 | 167 | 954 | 63 | 1,017 |
| Charger | 3 | 620 | 10.0 | 1,860 | 186 | 56 | 74 | 316 | 78 | 394 |
| Total | -- | -- | -- | 27,933 | 3,038 | 838 | 1,117 | 4,993 | 470 | 5,463 |
| Grand total | -- | -- | -- | 30,333 | 3,238 | 910 | 1,213 | 5,361 | 506 | 5,867 |
| *Stock selector* | | | | | | | | | | |
| Stock selector (2,500-pound capacity, 24-volt, 144-inch lift) | 5 | 6,500 | 10.0 | 32,500 | 3,250 | 975 | 1,300 | 5,525 | 487 | 6,012 |
| Battery | 5 | 1,500 | 6.3 | 7,500 | 1,190 | 225 | 300 | 1,715 | 115 | 1,830 |
| Charger | 5 | 600 | 10.0 | 3,000 | 300 | 90 | 120 | 510 | 400 | 910 |
| Total | -- | -- | -- | 43,000 | 4,740 | 1,290 | 1,720 | 7,750 | 1,002 | 8,752 |
| Grand total | -- | -- | -- | 43,000 | 4,740 | 1,290 | 1,720 | 7,750 | 1,002 | 8,752 |
| *"U" bay* | | | | | | | | | | |
| Tow tractor (24 volts, with coupler) | 4 | 1,875 | 10.0 | 7,500 | 750 | 225 | 300 | 1,275 | 113 | 1,388 |
| Battery | 4 | 539 | 6.3 | 2,156 | 342 | 65 | 86 | 493 | 32 | 525 |
| Charger | 4 | 375 | 10.0 | 1,500 | 150 | 45 | 60 | 255 | 258 | 513 |
| Total | -- | -- | -- | 11,156 | 1,242 | 335 | 446 | 2,023 | 403 | 2,426 |
| Trucks with coupler | 30 | 160 | 12.0 | 4,800 | 400 | 144 | 192 | 736 | 72 | 808 |
| Counterbalanced forklift truck (2,500-pound capacity, 24-volt electric, stand-up rider type, 167-inch lift) | 3 | 7,300 | 10.0 | 21,900 | 2,190 | 657 | 876 | 3,723 | 329 | 4,052 |
| Battery | 3 | 1,391 | 6.3 | 4,173 | 662 | 125 | 167 | 954 | 63 | 1,017 |
| Charger | 3 | 620 | 10.0 | 1,860 | 186 | 56 | 74 | 316 | 78 | 394 |
| Total | -- | -- | -- | 27,933 | 3,038 | 838 | 1,117 | 4,993 | 470 | 5,463 |
| Grand total | -- | -- | -- | 43,889 | 4,680 | 1,317 | 1,755 | 7,752 | 945 | 8,697 |

TABLE 11.—*Selected equipment requirements and costs in warehouses using 4 methods of assembling institutional grocery orders with $6 million in annual sales*—Continued

| Selection method and equipment | Amount [1] | Unit price [2] | Years depreciated [3] | Investment | Ownership costs | | | | Maintenance and other costs | Total annual costs |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Depreciation [4] | Interest (6 percent) [5] | Insurance and taxes (4 percent) | Total | | |
| *Batch* | *Number* | | *Number* | | | | | | | |
| Pallet jack (4,000 pound-capacity, 12-volt electric machine) | 5 | $2,600 | $10.0 | $13,000 | $1,300 | $390 | $520 | $2,210 | $195 | $2,405 |
| Battery | 5 | 500 | 6.3 | 2,500 | 397 | 75 | 100 | 572 | 38 | 610 |
| Charger | 5 | 550 | 10.0 | 2,750 | 275 | 83 | 110 | 468 | 177 | 645 |
| Total | -- | -- | -- | 18,250 | 1,972 | 548 | 730 | 3,250 | 410 | 3,660 |
| Counterbalanced forklift truck (2,500-pound capacity, 24-volt electric, stand-up rider type, 167-inch lift) | 3 | 7,300 | 10.0 | 21,900 | 2,190 | 657 | 876 | 3,723 | 329 | 4,052 |
| Battery | 3 | 1,391 | 6.3 | 4,173 | 662 | 125 | 167 | 954 | 63 | 1,017 |
| Charger | 3 | 620 | 10.0 | 1,860 | 186 | 56 | 74 | 316 | 78 | 394 |
| Total | -- | -- | -- | 27,933 | 3,038 | 838 | 1,117 | 4,993 | 470 | 5,463 |
| Grand total | -- | -- | -- | 46,188 | 5,010 | 1,386 | 1,847 | 8,243 | 880 | 9,123 |

[1] Based on data in table 2.
[2] Investment in handling equipment is listed as reported by manufacturers and by wholesale grocers included in this study.
[3] Depreciation is based on U.S. Internal Revenue Service Bulletin "F" and reasonable life expectancy.
[4] Straight-line depreciation.
[5] Imputed interest is at a rate of 6 percent per year for ½ the equipment life prorated over the full life.

not be considered as the cost of financing the purchase of the listed equipment. Insurance and taxes are based on the experience of several firms in different locations in the country. Individual firms may experience different rates.

Maintenance and other costs include charges for operating and repairing the equipment as well as the cost of maintenance performed on a regular basis to prevent unnecessary damage and wear. These charges are based on manufacturers' recommendations and the experience of the wholesale grocers in this study.

The equipment listed in table 11 is considered typical of the kind in use by firms using each of the four order-selection systems. The data in this table are not intended as a recommendation of particular types of equipment, such as forklift trucks, pallet jacks, and stock selectors. Many different kinds of materials-handling equipment are available to the modern wholesale grocer. Firms using each of the handling systems described in this report may use different materials-handling equipment to perform similar operations. Choice of a particular type of such equipment within broad categories often reflects the individual preference of a particular wholesale grocer.

## Building and Pallet-Rack Costs

To make a more meaningful comparison between the building costs in the four methods of assembling institutional grocery orders, certain adjustments were made in the floorspace used by the warehouses illustrated in figures 7–9. The adjusted floorspace requirements form the basis of the investment requirements in table 9. These adjustments were based on the assumption that each of the example firms would require the same number of selection and reserve pallet positions. In practice, the number of selection and reserve pallet positions could be expected to vary slightly between firms with the same annual sales depending on local business conditions. Since all the example firms were assumed to handle $6 million in annual sales, approximately 2,516 selection pallet positions and 4,858 reserve pallet positions should be available within any of the warehouses. Selection positions for fast-moving items are included as part of the total number of reserve pallet positions as both reserve storage and fast-moving item selection may involve pallets stacked one or more high directly on the warehouse floor.

The adjustments in warehouse space requirements were calculated in the following manner:

The layout shown in figure 7, designed for conventional and batch selection, provides 2,516 selection pallet positions and 4,858 reserve pallet positions in 45,771 square feet of warehouse space (table 1). No adjustment was required.

When the layout for stock selector selection (fig. 8) was designed, some additional space was required to develop a warehouse that would promote handling efficiency. This extra space resulted in a layout with 2,632 selection pallet positions and 5,868 reserve pallet positions and represented 116 selection pallet positions and 1,010 reserve pallet positions more than was necessary to handle the annual sales volume. These additional pallet positions required a total of 5,174 square feet of floorspace. The shaded sections in figure 11 illustrate this space and represent 850 square feet of excess space for selection and 4,324 square feet of excess space for reserve. This floorspace was subtracted from the square footage in the original layout, leaving 48,946 square feet of warehouse to form the basis of the building cost for stock selector selection shown in table 9.

A similar approach was followed in adjusting the floorspace requirements in the layout designed for "U" bay selection. The warehouse shown in figure 9 totals 55,626 square feet with 2,832 selection pallet positions and 5,632 reserve pallet positions. To adjust the number of selection and reserve pallet positions to the common basis discussed previously, the floorspace required for 316 selection pallet positions (4,350 square feet) and 774 reserve pallet positions had to be eliminated. Approximately 474 of the surplus reserve pallet positions would be overhead in the same racks holding the extra selection pallet positions. The remaining 300 surplus reserve pallet positions would occupy 4,350 square feet of warehouse floorspace. This extra floorspace is illustrated in figure 12. These unneeded pallet positions re-

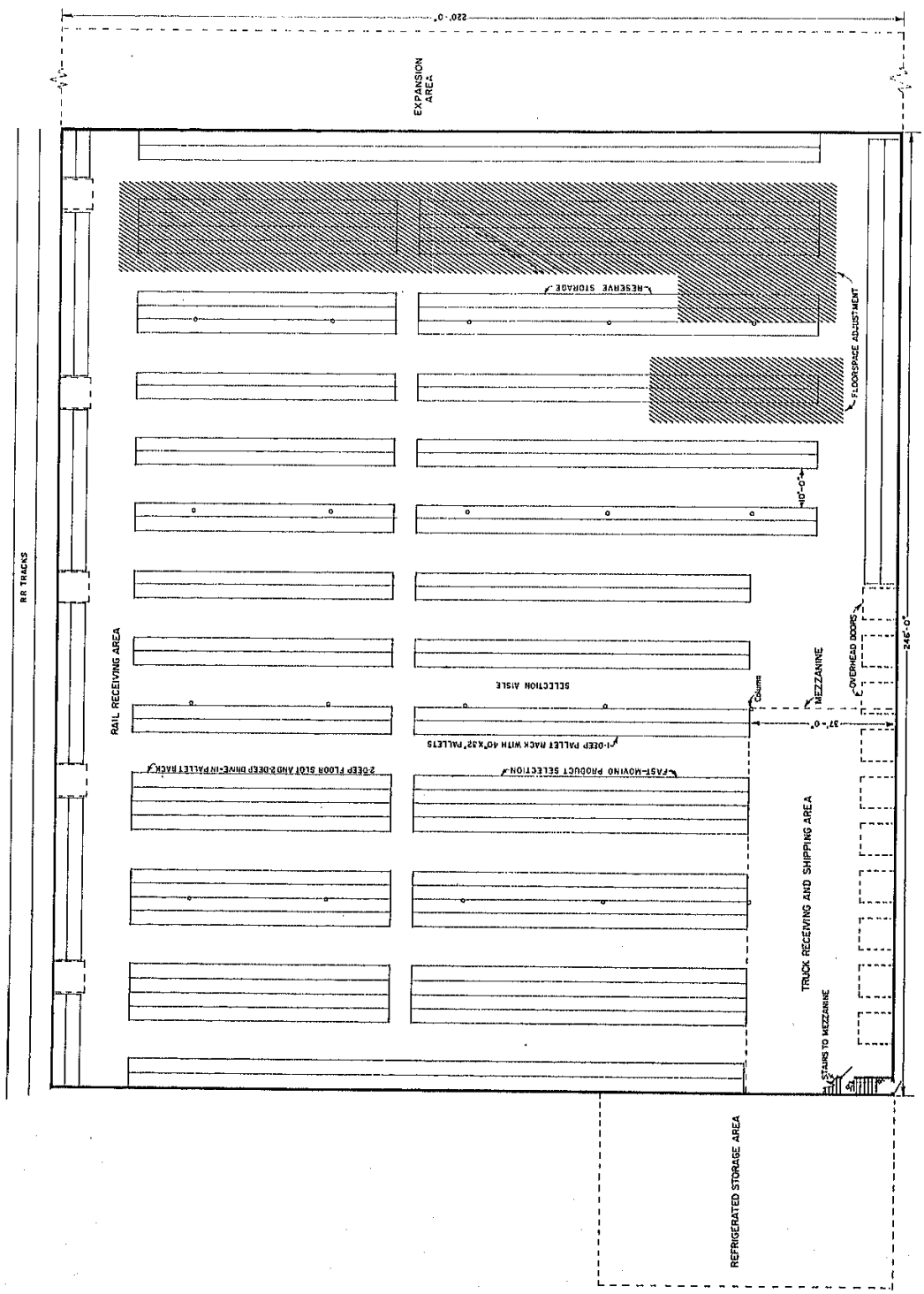


FIGURE 11.—Warehouse layout for stock selector selection with floorspace adjustment.

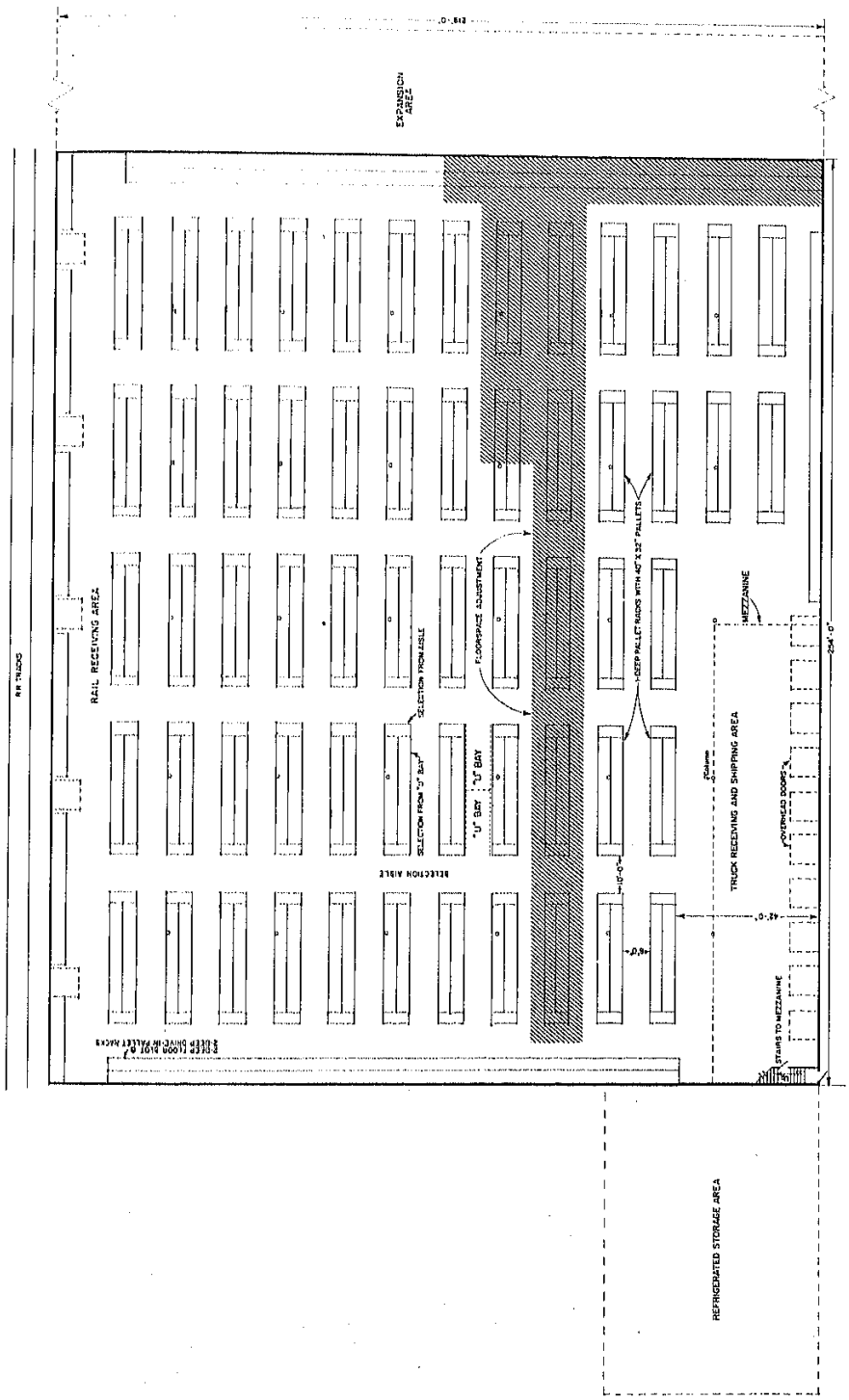


FIGURE 12.—Warehouse layout for "U" bay selection with floorspace adjustment.

quired a total of 5,694 square feet of warehouse floorspace. Eliminating this space from the layout shown in figure 9 left 49,932 square feet of building to be included in the costs shown in table 9.

Costs for pallet racks were based on the adjusted layouts. Similar rack costs were developed for conventional, "U" bay, and batch selection, resulting from identical demands for selection slots. Rack costs for stock selector selection differed from those of the other systems because of special layout requirements of this system in selecting orders. With this stock selector system, complete separation of selection from reserve storage is used. As a result, rack sections could be used completely for selection. Reserve storage was largely located in reserve storage areas with pallets stacked one on top of another.

The pallet-rack costs and requirements cited in this report are intended only for illustration. They could be expected to vary among wholesale grocers with the same annual sales depending on local costs, business conditions, and locations.

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